Effects of weight and stability

Lesson topic 3.4

Enabling objectives

1. Determine the trim and heel of the vessel and recommend actions to correct the condition
2. Select terms and abbreviations associated with stability and buoyancy

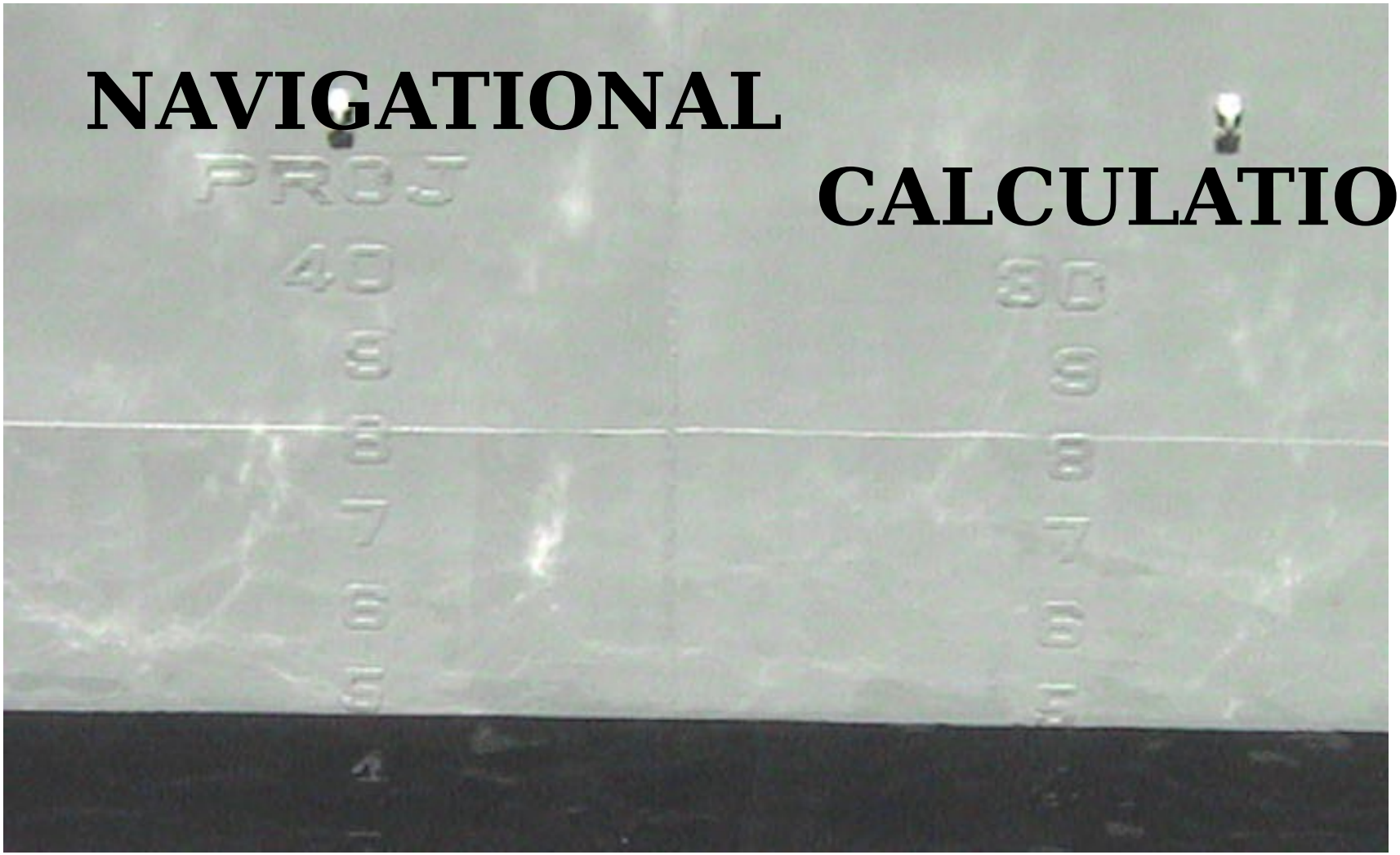
Shipboard draft marks

- Roman numerals, (calculation marks)
  - Used for measuring draft of the vessel from keel to waterline
  - Determines displacement
  - Numerals are 3 inches in vertical projected height
  - Read at bottom of mark for whole feet
  - Read at bottom of horizontal bar for 1/2 foot
  - Bar is 1 inch wide

Shipboard draft marks

- Arabic numerals, (navigational drafts)
  - Used to indicate operating drafts
  - Projections, if any, below the keel
  - Numerals are 6 inches in vertical projected height
  - Read at bottom of mark for whole feet
  - Read at top of mark for 1/2 foot
  - Used primarily by ship's navigator

Shipboard draft marks



Shipboard draft marks

- Limiting draft mark
  - If exceeded, ship's ability to survive damage or heavy weather is jeopardized
  - Located near draft numerals or amidships
  - Decision to exceed mark rests with the CO of the ship
- Internal draft indicators
  - Installed in larger ships
  - Draft can be read using remote draft gauge in DC Central

Clinometers

- Hermetically sealed glass tube containing liquid which is mounted on a calibrated board
- Installed at vital stations
- Most accurate under static conditions (fixed angles of Heel or List)
- Four types, (A, B, C, and E)
- Types A and B are used to determine trim
- Types C and E are used to determine heel or list

Clinometer

Definitions of Terms Associated with Ship's Stability

- Buoyancy
  - Tends to force the object back up out of the water
  - Upward force is equal to weight of water which the object displaces
- Reserve buoyancy
  - Volume of the watertight portion of the ship above the water line
- Displacement
  - The weight of the volume of water displaced by the hull, Weight of the ship.

Definitions of Terms Associated with Ship's Stability

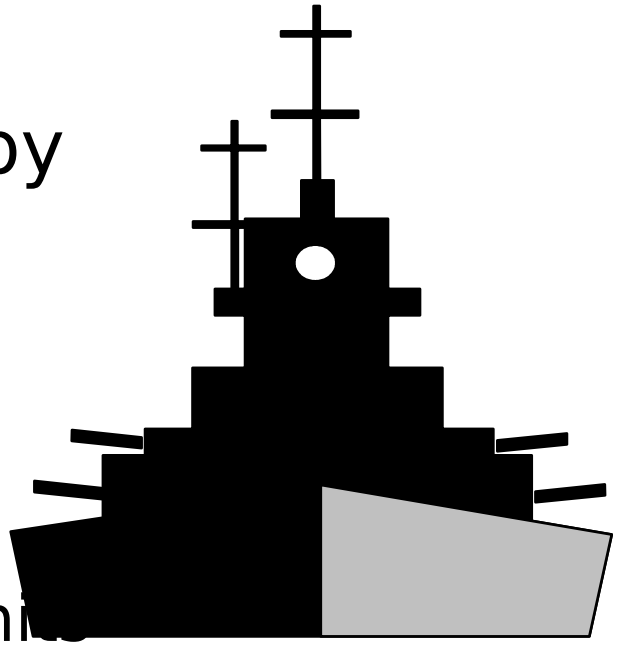
- Stability
  - Tendency to remain or return to an upright position
- Center of Buoyancy
  - Upward force acting in a vertical line through the center of the volume displaced
- Center of Gravity
  - Force of gravity (weight) of the ship's structure and contained load acts vertically downward

Principles of stability

- Floating body is acted on by two forces
  - Gravity
  - Buoyancy
- Objects exist in three states
  - Stable
  - Neutral
  - Unstable

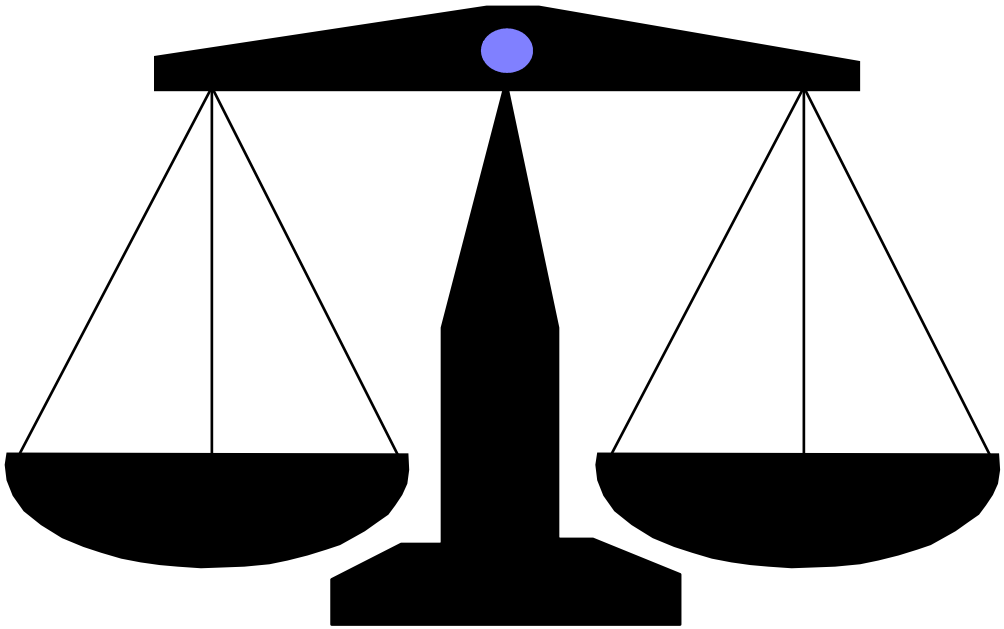
Forces Acting on Ship's Stability

- Centers of buoyancy & gravity must lie in the same vertical line
- Ship is disturbed from rest by
  - Wave action
  - Wind pressure
  - Turning forces
  - Recoil of gunfire
  - Impact of collision or enemy hit
  - Shifting of weights onboard
  - Additional/removal of off center weights



Forces Acting on Ship's Stability

- "Stable Ship" develops a tendency to right itself
  - Called a "Righting Moment"



Principles of Heel, Roll, List, and Trim

- Heel: Athwartships (side to side) inclination
  - Roll: Alternate Heeling from side to side
  - List: Permanent angle of Heel
  - The major cause of listing is off-center weight
- Trim
  - Distribution of weight so that the ship sits well in the water forward and aft
  - Determined by difference between forward and after draft

Effects of Weight on Ship Stability

- Weight additions, removals and shifts
  - The addition or removal of weight will always change the draft readings, and may effect trim, list and overall stability
- Causes of off center weight
  - Flooding in compartments off the centerline
  - Pumping liquids across the ship
  - The shifting of ammunition, cargo, or personnel, across the ship

Effects of Weight on Ship Stability

- Correcting for off-center weight
  - Shifting weights from the listed side to the high side
  - Jettisoning topside weights
  - Drain loose water
  - Suppressing free surface
  - More drastic measures, such as completely filling partially flooded spaces, require careful consideration and are usually a last resort

Free Communication with the Sea Effect (off centerline)

- Occurs when a compartment is partially flooded,
- Effect is increased as the ship rolls
- The movement of the water as the ship rolls exerts a strong, dynamic force on the bulkheads
- As more water is taken in, draft increases.
- Results in stability being greatly reduced

Ship's Flooding Effects and Liquid Load DC Diagram plate 1

- Flooding effect diagram
  - Flooding effect portion of this plate is to show the effect of flooded compartments on the ships stability
  - Compartments on the flooding effect diagram are color coded
    - Pink - Flooding of the compartment results in a decrease in stability
    - Green - Flooding of the compartment improves stability, even though free surface exists

Compartments on the flooding effect diagram are color coded as follows

- Yellow - Flooding of the compartment improves stability when completely filled, but stability is impaired when free surface exists
- White or Uncolored - Flooding of the compartment will have no appreciable effect on the stability of the ship

Ship's Flooding Effects and Liquid Load DC Diagram plate 1

- In the Flooding Effect part of this plate, the three numbers in the compartment represent
  - Center, compartment number(s)
  - Left upper, capacity in tons, S.W
  - Right lower, moment Ft. tons

Ship's Flooding Effects and Liquid Load DC Diagram plate 1

- Liquid load diagram
  - Tanks and voids that are fitted to carry liquids
  - In the Liquid loading part of this plate, the five numbers in the compartment represent
    - Center, compartment number
    - Left upper, capacity in tons, (filled with cargo)
    - Left lower, change in draft aft, (when flooded)
    - Right upper, list/degrees
    - Right lower, change in draft fwd, (when flooded)
  - Tanks are color coded to indicate use

Watertight integrity

- Maintained to keep the ship stable
- Flooding in spaces could result in change to
  - Buoyancy
  - Center of gravity
  - Displacement
- Maintain correct material conditions to avoid flooding & aid in fire/smoke containment

Summary and Review

- Shipboard Draft Marks
- Definitions of terms associated with ship's stability
- Principles of Stability
- Forces acting on ship's stability
- Principles of Heel, Roll, List, and Trim
- Effects of weight on Ship Stability
- Free Communication with the Sea Effect

Summary and Review

- Ship's Flooding Effects and Liquid Load Diagrams (Isometric Damage Control Diagram number One)
- Watertight Integrity